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UH-1H DOWNWASH VELOCITY MEASUREMENTS

ARMY ENGINEER WATERWAYS EXPERIMENT STATION
VICKSBURG, MISSISSIPPI

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UH-1H DOWNWASH VELOCITY MEASUREMENTS

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Grady W. Leese

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Field measurements were made to determine the velocity of the horizontal and vertical downwash flow beneath the rotor of a UH-1H helicopter. Maximum downwash velocities measured during 7-sec periods were as follows:

Direction of Flow	Distance from Center of Rotor Rotation, ft	Aircraft Position		Maximum Downwash Velocity mph	Remarks
		Hover Height ft	Heading* deg		
Horizontal	41	10	360	59	--
Vertical	29	30	270	30	6' above ground

*Referenced to instrument line:

360-deg heading, aircraft facing line.

270-deg heading, aircraft rotated 90 deg left.

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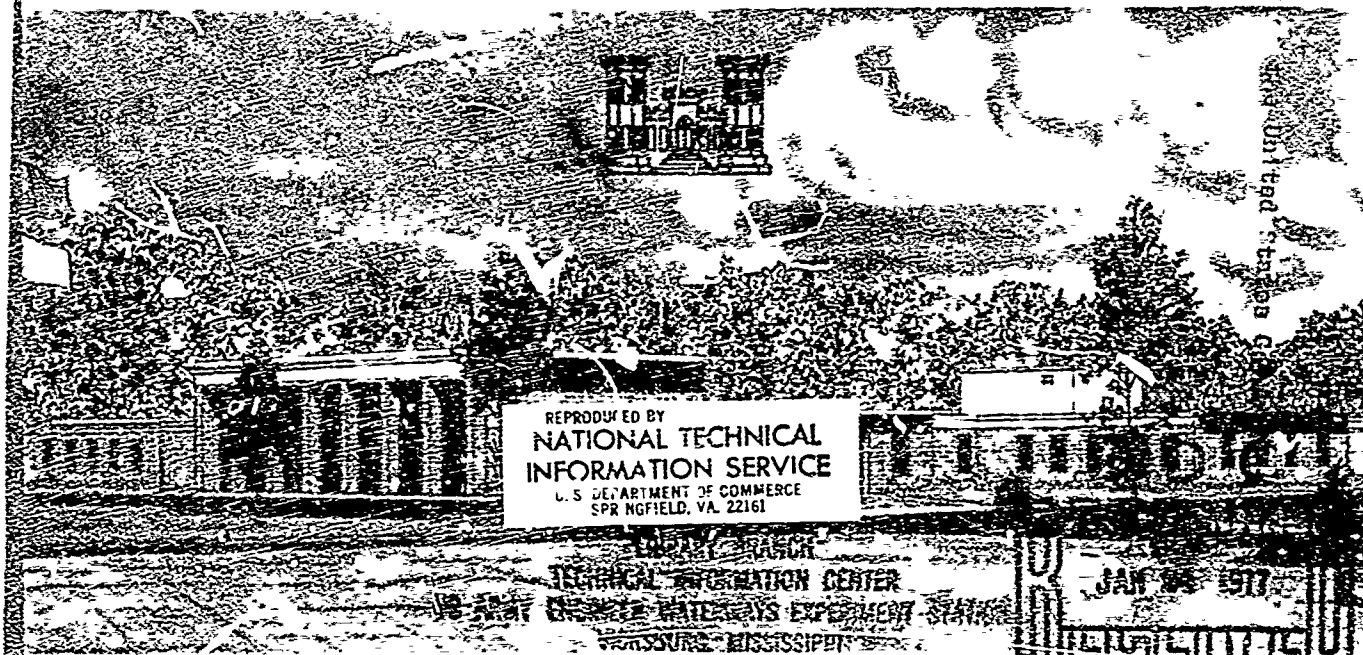
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UH-1H DOWNWASH VELOCITY MEASUREMENTS

by

G. W. Leese

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Engineer Waterways Experiment Station
Vicksburg, Mississippi



August 1972

Sponsored by U. S. Army Mobility Equipment Research and Development Center
Fort Belvoir, Virginia

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Soils and Pavements Laboratory
Vicksburg, Mississippi

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FOREWORD

Authorization for this investigation was contained in a letter dated 20 April 1972 from the U. S. Army Mobility Equipment Research and Development Center (MERDC), Ft. Belvoir, Va., subject: Intra Army Order for Reimbursable Services No. A2297.

The data reported herein were obtained during 1972 by personnel of the U. S. Army Engineer Waterways Experiment Station (WES), Soils and Pavements Laboratory under the general supervision of Messrs. J. P. Sale, R. G. Ahlvin, and W. L. McInnis, and under the direct supervision of Mr. G. W. Leese. Mr. W. J. McNamara (MERDC) prepared the plan of test and made necessary arrangements with the U. S. Army Aeromedical Laboratory, Ft. Rucker, Ala., for use of the aircraft and airfield. COL W. P. Shane, assisted by CPT G. R. McCahan, Jr., Ft. Rucker, not only made arrangements for aircraft, personnel, and equipment for this study at the airfield at Apalachicola, Fla., but assisted WES personnel in performing the tests.

COL Ernest D. Peixotto, CE, was Director during the study and preparation of this report. Mr. F. R. Brown was Technical Director.

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CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
inches	2.54	centimeters
feet	0.3048	meters
pounds	0.45359237	kilograms
miles per hour	1.609344	kilometers per hour

SUMMARY

Field measurements were made to determine the velocity of the horizontal and vertical downwash flow beneath the rotor of a UH-1H helicopter. Maximum downwash velocities measured during 7-sec periods were as follows:

Direction of Flow	Distance from Center of Rotor Rotation, ft	<u>Aircraft Position</u>		Maximum Downwash Velocity mph	Remarks
		Hover Height ft	Heading* deg		
Horizontal	41	10	360	59	--
Vertical	29	30	270	30	6' above ground

*Referenced to instrument line:

360-deg heading, aircraft facing line

270-deg heading, aircraft rotated 90 deg left

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UH-1H DOWNWASH VELOCITY MEASUREMENTS

Introduction

1. The purpose of this investigation was to obtain field measurements of the horizontal and vertical downwash flow beneath the rotor of the UH-1H helicopter. These measurements were obtained by placing velocity transducers in a test area at the airfield at Apalachicola, Fla., and recording data as aircraft hovered in various positions in relation to the instruments.

Aircraft

2. The aircraft utilized in this study was the standard version of the UH-1H helicopter, which is a turbine-driven, single-rotor aircraft with a rotor diameter of 48 ft* and a gross weight of 8540 lb as tested. The distance between the aircraft skids and rotor actuator plane is 13 ft. The aircraft was equipped with a radio altimeter, which was used during these tests to maintain heights above the ground plane.

Instrumentation

3. Instrumentation consisted of velocity transducers of the voltage generation type using a 4-in.-diam propeller to sense the downwash velocity. The instruments were placed on the concrete apron of the airfield as shown in plate 1. There were six stands, each of which held six transducers. The stands were constructed so as to measure downwash velocities at heights of 2, 4, and 6 ft above the ground surface and were spaced 4 ft apart on the apron. The stands were mounted 12 deg off perpendicular in direction to the UH-1H helicopter rotation to prevent any interference among the vertical velocity transducers on the stands. Also, there were velocity transducers on the ground surface to measure ground surface; these transducers were spaced 4 ft apart, as shown in plate 1. The velocity transducers were calibrated in the WES wind tunnel just prior to and after the

* A table for converting British units of measurement to metric units is presented on page vii.

tests to ensure accurate calibrations. The outputs of the velocity transducers were recorded using an oscillograph. Photograph 1 shows a general view of the test area looking in the direction of ground-wash flow, while photograph 2 shows a close-up of the stands and the arrangement of the velocity transducers.

Test Procedures and Results

4. Tests were conducted to determine the velocity of the horizontal and vertical downwash from the helicopter rotor of a UH-1H helicopter hovering at skid heights of 10, 30, and 70 ft above the ground surface. The aircraft was positioned by personnel on the ground instructing the pilot as to necessary movements.

5. Vertical and horizontal downwash velocity measurements were made at 2, 4, and 6 ft above the ground surface at distances of 9, 13, 17, 21, 25, and 29 ft from the center of rotor rotation on the helicopter and at headings of 270, 300, 330, 360 deg. (Aircraft heading referenced to instrument line: 360-deg heading would be when the aircraft was facing the line of instruments; 330 deg when rotated 30 deg to left, etc.) Horizontal ground-wash measurements were made at the ground surface beneath each stand and also at distances of 0, 33, 37, 41, 45, 49, 53, 57, 61, 65, and 73 ft from the same center of rotor rotation. Simultaneous recordings were made of the output from all transducers. Data recordings were made only after the pilot indicated that the helicopter was stabilized, thus having the minimum of control input to the aircraft.

6. Simultaneous readings of downwash velocity with the aircraft hovering with rotor center of rotation over pickup 54 are shown in tables 1 and 2. Tables 3 and 4 give the maximum velocities attained during each test condition over a period of seven seconds. Maximum horizontal downwash velocity recorded during this time period was 59 mph at a distance of 41 ft from center of rotor rotation when the aircraft was at 10-ft hover height and 360-deg heading. Maximum vertical downwash velocity during this period was 30 mph at a vertical height of 6 ft above the ground surface and 29 ft from the center of rotor rotation when the aircraft was

at 30-ft hover height and 270-deg heading. Comparisons of tables 1 and 2 and 3 and 4 indicate that most of the flow was in the horizontal plane. To verify this, personnel walked beneath the hovering aircraft and could feel very little downward flow; they noted that the instrument propellers measuring vertical flow were rotating very slowly or not at all.

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UH-1H DOWNWASH VELOCITY STUDY
SIMULTANEOUS HORIZONTAL VELOCITIES

* See plate 1

Table 1 (concluded)

Skid Height		10 ft				30 ft				70 ft			
Above Surface		360°				360°				360°			
Aircraft Heading*		330°				330°				330°			
Test No.		2				6				10			
Velocity Pickup		270°				270°				270°			
No.		3				7				11			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
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Velocity Pickup		270°				270°				270°			
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Velocity Pickup		270°				270°				270°			
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Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
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Velocity Pickup		270°				270°				270°			
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No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			
Velocity Pickup		270°				270°				270°			
No.		4				8				12			

Table 2
UH-1H DOWNWASH VELOCITY STUDY
SIMULTANEOUS VERTICAL VELOCITIES

Velocity Pickup No.	Skid Height		10 ft		30 ft		70 ft	
	Above Surface		300°		300°		300°	
	Aircraft Heading*	Test No.	360°	330°	360°	330°	360°	330°
13	2 ft	1	1	2	5	6	9	10
15	4 ft							
17	6 ft							
21	2 ft							
23	4 ft			14				
25	6 ft				1			
27	2 ft							
29	4 ft				2			
31	6 ft							
35	2 ft				6			
37	4 ft							
39	6 ft			8		3	3	
41	2 ft							
43	4 ft							
45	6 ft			5				
49	2 ft							
51	4 ft							
53	6 ft							

Velocity, mph

* See plate 1

Table 3
UH-1H DOWNWASH VELOCITY STUDY
MAXIMUM HORIZONTAL VELOCITIES

Skid Height		10 ft			30 ft			70 ft		
Above Surface		360°	330°	300°	360°	330°	300°	360°	330°	300°
Aircraft Heading*		1	2	3	5	6	7	9	10	11
Velocity Pickup No.	Velocity Pickup Height Above Surface	Velocity, mph								
		39	43	49	54	51	53	52	51	50
1	4 in.	37	41	43	43	47	48	45	41	38
2	4 in.	47	47	47	47	47	47	47	47	47
3	4 in.	47	47	47	47	47	47	47	47	47
4	4 in.	47	47	47	47	47	47	47	47	47
5	4 in.	47	47	47	47	47	47	47	47	47
6	4 in.	47	47	47	47	47	47	47	47	47
7	4 in.	47	47	47	47	47	47	47	47	47
8	4 in.	47	47	47	47	47	47	47	47	47
9	4 in.	47	47	47	47	47	47	47	47	47
10	4 in.	47	47	47	47	47	47	47	47	47
11	4 in.	47	47	47	47	47	47	47	47	47
12	4 in.	47	47	47	47	47	47	47	47	47
14	2 ft	47	47	47	47	47	47	47	47	47
16	4 ft	47	47	47	47	47	47	47	47	47
18	6 ft	47	47	47	47	47	47	47	47	47
19	4 in.	47	47	47	47	47	47	47	47	47
20	2 ft	47	47	47	47	47	47	47	47	47
22	4 ft	47	47	47	47	47	47	47	47	47
24	6 ft	47	47	47	47	47	47	47	47	47
26	4 in.	47	47	47	47	47	47	47	47	47
28	2 ft	47	47	47	47	47	47	47	47	47
30	4 ft	47	47	47	47	47	47	47	47	47
32	6 ft	47	47	47	47	47	47	47	47	47
33	4 in.	47	47	47	47	47	47	47	47	47
34	2 ft	47	47	47	47	47	47	47	47	47

* See plate 1

sheet 1 of 2

Table 3 (cont'd)

Skid Height		10 ft			30 ft			70 ft		
Above Surface		360°			360°			360°		
Aircraft Heading*		330°			330°			330°		
Test No.		2			6			10		
Velocity Pickup		270°			270°			270°		
Height Above Surface		3			7			11		
No.		4			8			12		
Velocity Pickup		5			9			10		
No.		6			14			16		
Velocity Pickup		7			16			23		
No.		8			23			23		
Velocity Pickup		9			23			23		
No.		10			23			23		
Velocity Pickup		11			23			23		
No.		12			23			23		
Velocity Pickup		13			23			23		
No.		14			23			23		
Velocity Pickup		15			23			23		
No.		16			23			23		
Velocity Pickup		17			23			23		
No.		18			23			23		
Velocity Pickup		19			23			23		
No.		20			23			23		
Velocity Pickup		21			23			23		
No.		22			23			23		
Velocity Pickup		23			23			23		
No.		24			23			23		
Velocity Pickup		25			23			23		
No.		26			23			23		
Velocity Pickup		27			23			23		
No.		28			23			23		
Velocity Pickup		29			23			23		
No.		30			23			23		
Velocity Pickup		31			23			23		
No.		32			23			23		
Velocity Pickup		33			23			23		
No.		34			23			23		
Velocity Pickup		35			23			23		
No.		36			23			23		
Velocity Pickup		37			23			23		
No.		38			23			23		
Velocity Pickup		39			23			23		
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Velocity Pickup		41			23			23		
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Velocity Pickup		47			23			23		
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Velocity Pickup		49			23			23		
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No.		54			23			23		
Velocity Pickup		55			23			23		
No.		56			23			23		
Velocity Pickup		57			23			23		
No.		58			23			23		
Velocity Pickup		59			23			23		
No.		60			23			23		
Velocity Pickup		61			23			23		
No.		62			23			23		
Velocity Pickup		63			23			23		
No.		64			23			23		
Velocity Pickup		65			23			23		
No.		66			23			23		
Velocity Pickup		67			23			23		
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Velocity Pickup		77			23			23		
No.		78			23			23		
Velocity Pickup		79			23			23		
No.		80			23			23		
Velocity Pickup		81			23			23		
No.		82			23			23		
Velocity Pickup		83			23			23		
No.		84			23			23		
Velocity Pickup		85			23			23		
No.		86			23			23		
Velocity Pickup		87			23			23		
No.		88			23			23		
Velocity Pickup		89			23			23		
No.		90			23			23		
Velocity Pickup		91			23			23		
No.		92			23			23		
Velocity Pickup		93			23			23		
No.		94			23			23		
Velocity Pickup		95			23			23		
No.		96			23			23		
Velocity Pickup		97			23			23		
No.		98			23			23		
Velocity Pickup		99			23			23		
No.		100			23			23		

Table 4

UH-1H DOWNWASH VELOCITY STUDY
MAXIMUM VERTICAL VELOCITIES

Skid Height		10 ft		30 ft		70 ft	
Above Surface		330°		330°		330°	
Aircraft Heading*		300°		300°		300°	
Test No.		270°		270°		270°	
Velocity Pickup		3		7		11	
Height Above		4		8		12	
Surface		4		16		23	
No.		3		9		7	
Velocity, mph		9		12		18	
13	2 ft	-	-	9	12	8	-
15	4 ft	-	-	13	11	9	-
17	6 ft	-	-	25	27	21	-
21	2 ft	-	-	7	7	-	-
23	4 ft	-	-	11	13	16	-
25	6 ft	-	-	-	-	23	-
27	2 ft	-	-	9	8	-	-
29	4 ft	-	-	10	10	20	-
31	6 ft	-	-	19	13	24	-
35	2 ft	-	-	-	3	7	-
37	4 ft	-	-	10	18	27	-
39	6 ft	-	-	-	-	-	-
41	2 ft	-	-	-	6	-	-
43	4 ft	-	-	-	5	-	-
45	6 ft	-	-	-	8	-	-
49	2 ft	-	-	-	-	-	-
51	4 ft	-	-	-	-	-	-
53	6 ft	-	-	-	9	7	-

* See plate 1



Photo 1. General view of UH-1H downwash measurements test area



Photo 2. Instrumentation for above-ground measurements

